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CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER

PUBLICATIONS DE CIRCONSTANCE

N° 8-9

T. WEMYSS FULTON

8

ON THE SPAWNING OF THE COD (*GADUS MORRHUA* L.)
IN AUTUMN IN THE NORTH SEA

WITH A CHART

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A NEW MARK FOR FISH

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

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ON THE SPAWNING OF THE COD (*GADUS MORRHUA* L.) IN AUTUMN IN THE NORTH SEA

BY

T. WEMYSS FULTON

WITH A CHART

LAST autumn I became aware that considerable numbers of sexually ripe cod were being landed at Aberdeen. On enquiry it was ascertained that they were all caught on an area of stony ground lying between seventy and eighty miles off the coast of Norway, westwards of Jæderens Point, the (magnetic) direction and the distance from Aberdeen, as given by the fishing vessels engaged in catching the cod, being 180—190 miles East-by-North or E. $^3/_4$ N. As shown on Olsen's chart of the North Sea, this patch of rough ground (known to the Aberdeen fisherman as the "Reef" or "Rough") lies in Lat. 58° 30′ to 58° 47′ N. and Long. 3° E. (Plate I). It is oblong in shape, extending north and south for about seventeen miles and east to west for about ten miles, between the fifty fathom and sixty fathom lines. It is thus situated close to the deep-water of the Norwegian Channel, about fifteen miles from the 100-fathom line and twenty-six miles from the 150-fathom line. There are other patches of stony ground in the vicinity, viz. about ten miles to the west-by-south and to the south-east, in shallower water; to the north, in 60—75 fathoms, and east and north on the edge of the Udsire Hole, in 130—140 fathoms. It appears however that the cod are not got on these grounds, but are confined to the area described. They are caught by steam-liners, and only on the "rough"; trawlers working in the neighbourhood only occasionally get a mature cod. According to the statement of the liners, the cod come upon the ground referred to about the middle or towards the latter part of August and early in September, and they are most numerous on the shallower part, in from 50 to 56 fathoms. — They are present in large numbers, the catch for one "shot" of the lines usually varying between 400 and 1000 cod, equal to from about 50

to 125 cwts (2540—6350 kilogrammes); and codling, ling, tusk (*Brosmius*) halibut, catfish, coalfish and skates are taken at the same time. The liners continue working on this ground until November, by which time the cod are very thin and much less abundant.

The cod are not gutted on board, but in the yards where they are prepared for distribution. An examination of the ovaries at the end of August and in September and October showed them to be in various conditions, from nearly ripe to quite ripe, with flowing eggs, and partly spent; and I was informed by the gutters and liners that this is the condition at the corresponding season each year. Townet collections taken from a fishing boat on the ground (surface to about 20 fathoms) on 8th October were examined by Dr H. C. Williamson, with the following result. The pelagic eggs of fishes numbered 80, of which 68 were gadoid eggs of the size of the eggs of cod (1.25 —1.4 mm) and fourteen of these were unmistakeably cod eggs, the characteristic embryonic pigment being well shown; seven eggs were apparently those of whiting (*Gadus merlangus*) three apparently those of lemon sole (*Pleuronectes microcephalus*) and two probably small eggs of whiting. There were 49 young fishes, viz. three larval cod, two whitings, 33 and 51 mm., two post-larval gadoids, one young ling, 24 mm., three post-larval pleuronectids, apparently lemon soles, 38 post-larval and young Rocklings (*Motella*) and one young *Fierasfer* sp. The invertebrates in the plankton were examined by Dr Thomas Scott; they included *Clione borealis, Limacina retroversa, Hyperia medusarum*, and a variety of copepods, the species indicating North Atlantic water.

The temperature of the water on the ground on the 8th October was: surface 10°.9 C, bottom (60 fathoms) 6°.7 C, while the temperature of the air was 9°.2 C. The nearest "International" Stations are D North Sea 5, 6, 7 and Sc 23, 24, 25. The temperatures at these in the August and November series 1903 were as follows:

Month	Depth in m	Temp. °C. at D North Sea 5	Temp. °C. at D North Sea 6	Temp. °C. at D North Sea 7	Depth in m	Temp. °C. at Sc 23	Temp. °C. at Sc 24	Temp. °C. at Sc 25
August 1903	40	7.0	6.51	6.45	40	10.33	9.73	10.09
	50	7.0	6.53	7.06	60	6.80	7.23	8.73
	60—62	7.0			80	6.77	6.89	8.33
	72		6.68	7.01	100	6.79	6.89	8.31
	100—101			6.53				
November 1903	40	9.10	9.32	10.32	40	8.12	8.20	8.70
	50	8.99	9.32	10.34	60	8.12	8.20	8.68
	59	8.98			80	7.10	6.80	8.68
	65				100	6.86	6.79	8.71
	75	....	7.78	9.18				
	93—95							
	100	....	7.78	8.01				

In order to ascertain the direction in which the floating eggs were likely to be carried, a number of drift-bottles were made use of to determine the surface drift, viz. at distances E. by N. of Aberdeen as follows (1) Eight on 7th October at 115 miles; (2) nine on 7th October at 164 miles; (3) forty on 8th October at 190 miles, on the Eastern part of the ground; (4) thirly-six on 3d November at 130 miles; (5) thirty on 9th November, on the ground, at 185 miles. The earliest to be returned were those of the second and third lots, and they came, unexpectedly, from the Shetland Islands. Two were found there on 22d October, fourteen and fifteen days respectively after having been thrown into the sea, and other ten between 27th Octbr. and 9th November. On 22d November another of the third lot was found at Romsdal in Norway. Four of the first lot were got on 22d and 23d November also on the west coast of Norway, two at Moldöen, one sixty kilometres south of Bergen and one at Silden; and four of the fourth lot were got on the south-west coast of Norway between 10th and 19th December, at Karmöen, near Stavanger, at Mandal, Lindesnæs, and East of Christianssand. Of the fifth series none have so far been received.

The movement towards the Shetlands at the beginning of October was no doubt temporary and due to a temporary cause, since my previous investigations on the surface drift have shown that the normal movement in the region in question is towards and along the Norwegian coast[1]) and it is extremely probable that the floating eggs and larval cod are carried in that direction as a rule — a fact which may help to explain the difficulties that have been encountered in determining the rate of growth of the fish.

The circumstance of the cod spawning in autumn in the North Sea is novel, and it may be well to consider the evidence which exists as to its normal spawning period in different places within the area of its distribution, which, according to Günther[2]) extends in the North Atlantic, on both sides from about 40° to 75° N. latitude, a distance of some 2000 miles. In the northerly part of this region information as to the spawning of the cod has been furnished by G. O. Sars, Hjort and Breitfuss. The former in his classical investigations at the Lofoten Islands showed that the floating eggs were to be found there from about the middle of February well into May, and were most abundant at the end of March when they "filled the sea"[3]).

[1]) Fifteenth Ann. Rep. Fishery B. for Scot. Part III. 350; Eighteenth ibid. 372. See also Åkerblom, Recherches océanographiques, Uppsala Universitets Årsskrift, 1903. p. 53. pl. IV. (1904).

[2]) An Introduction to the Study of Fishes. 1880. p. 540.

[3]) Indberetninger til Departementet for det Indre. pp. 16, 34, 57. (1879).

More recently Hjort found the floating eggs in great numbers in Vestfjord, Lofoten, and over the Coast banks to the west and north of the Lofotens, towards the North Cape, between 1st and 23d April, when the *Michael Sars* was there; further north in the sea between Finmarken and Bear Island and in the inshore waters and fjords of Finmarken, between 13th and 31st March, but in very small numbers; and also, still less abundantly, in the inshore waters eastwards to the Murman coast in May[1]). Further east off the Murman coast, according to Breitfuss, the cod spawns in the open sea from February to May[2]), but further particulars on this point are desirable.

In the North Sea the examination of 8542 cod on the East coast of Scotland from December to June inclusive, showed that spawning took place from the end of January to June, and mostly in March, the percentages of ripe fishes in the various months being: — January 0.9, February 16.2, March 40.0, April 16.7, May 10.0 and June 3.0[3]). Hensen & Apstein in their investigations on floating eggs found the maximum spawning of the cod in the North Sea to be about 12th March, in 1895; and they state their opinion that the spawning-period lasts for six months[4]). Heincke & Ehrenbaum also fix the maximum in the middle of March and the duration of the spawning period from January to June[5]). In the Firth of Forth the floating eggs of the cod were found from 19th February to 25th May[6]).

In the Irish Sea Herdman & Dawson state that the cod spawns in spring[7]) while on the West coast of Ireland Holt describes the spawning-period as probably commencing in February and extending to the end of May or into June, while the pelagic eggs were got plentifully in the townets in the latter part of March and in April[8]). On the West coast of Scotland, in Lochfyne, Firth of Clyde, Williamson procured the floating eggs from February to June but mostly in March and April; some were got in July and five in August[9]).

[1]) Fiskeri og Hvalfangst i det Nordlige Norge. p. 41, 44. (1902).

[2]) Verhandlungen des V. Internat. Zool. Congress, 1902. p. 984.

[3]) Fulton, Tenth Ann. Rep. Fishery Board for Scot. Part III. p. 233. (1892).

[4]) Wissenschaftl. Meeresuntersuchungen II. 2. p. 60. (1897).

[5]) Wissenschaftl. Meeresuntersuchungen. III. Abtheil. Helgoland 2. p. (1900).

[6]) Masterman, Fifteenth Ann. Report Fishery Board for Scotland, Part III, p. 222. (1897).

[7]) Fish and Fisheries of the Irish Sea. p. 46. (1902).

[8]) Survey of Fishery Grounds on the West Coast of Ireland. Roy. Dublin Soc. Report of the Council. 1891. p. 248. (1892).

[9]) Seventeenth Ann. Rep. Fishery Board for Scot. Part III. p. 97. (1899).

In the Baltic the floating eggs of the cod were procured by Hensen & Apstein at the end of December, and these authors say that spawning in a normal winter begins about 15th December and ends about the middle of May, the maximum occurring from about 17th February to the beginning of April[1]). Petersen found spawning cod in the Great Belt on 31st March and also in April, and he speaks of the deposition of the eggs in February, March and April[2]). On the other hand the authors of the History of Scandinavian Fishes[3]) say that in the inland belt at Bohuslän, the spawning season rarely commences before May, and that Lindström describes the spawning as occurring at Gothland in April.

In the report on the Danish investigations of the Diana on the south and east coasts of Iceland, in the years 1898—1900, Johansen states, on the authority of Commander Schultz, that the spawning-time of the cod on the south coast is from the "full moon in March to the full-moon in April", and that at the end of April the cod go off to sea. Cod ready to spawn were procured on the east coast by the Diana, after its arrival there, between the end of April and the middle of May, in 1898 and 1899[4]).

On the American coasts of the North Atlantic, the cod appears to begin spawning earlier than in European seas. The fullest account is contained in Earll's well-known report on the Cod Fisheries of Cape Ann in the season of 1878—79, his description applying to the northern part of Massachusetts. The cod were found to be most abundant from November to June, visiting the shores for the purpose of spawning in from 15 to 40 fathoms. The first ripe female was obtained on 2d September, and from this date onwards ripe males and females were occasionally taken, but they did not become abundant until the middle of October. Early in November some were found quite ripe or spawning, and others so "green" that it was clear to Earll that they would not spawn for several months. By 1st December 50 % of those examined had commenced to spawn; on 1st February, in Ipswich Bay, not more than ten per cent had spawned and fully 60 % were still "green", or unripe; by the middle of the month less than half had begun spawning; on 13st March of 300 examined 14 % were spent males, 53 % ripe males, 6 % spent females, 14 % spawning females and 11 % unripe females. On 10th May fully half of the females examined had not finished spawning and an

[1]) Loc. cit.

[2]) Rep. of the Danish Biological Station. XI. pp. 4, 8. (1904).

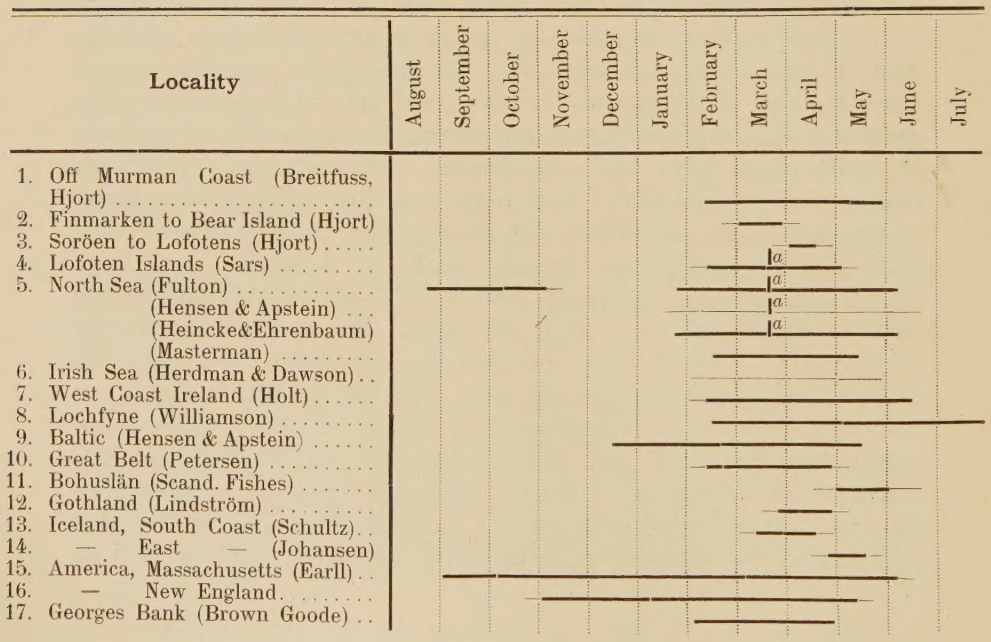
[3]) I. p. 477.

[4]) Fiskeri-Beretning for Finansaaret 1901—1902. p. 246. Kjøbenhavn 1903.

occasional unripe one was observed; even in June, when the fish left the coast, some of the females had not completed spawning. Thus Earll found the cod spawning in the same locality for nine consecutive months, from September to May; but there is little doubt from the detailed information, above summarised, that, as Hensen & Apstein remark, the shoals of cod observed during the period came from different regions, where, doubtless, the temperature or other conditions of growth materially differed [1]).

It is stated in other reports of the U. S. Fish Commission that the spawning-period of the cod on the New England coast extends from November, sometimes from October, to May; the collection of eggs for the Woods Hole hatchery begins about the middle of November and goes on to February, or even the end of March, and the brood fish in the basin begin spawning at the middle of November [2]). On the other hand Brown Goode & Collins speak of shoals of cod coming on to Georges Bank, on the west of Newfoundland, to spawn in from 25—30 fathoms, in February, March and April [3]).

Although the information concerning the limits of the spawning-period of the cod in the seas of Westen Europe is to some extent



[1]) Report U. S. Fish Commission for 1878. pp. 704, 713. (1880).

[2]) Report for 1901. p. 34. (1902). Manual of Fish-Culture. p.195. Washington, 1897.

[3]) The Fisheries and Fishery Industries of the United States. I. p. 189. (1884).

imperfect, the observations having been sometimes confined to a part of the period only, or to the study of the floating eggs exclusively — the diagnosis of which may perhaps in some cases be doubtful — yet there is sufficient evidence to reveal a remarkable uniformity in time throughout the area of distribution, at places remote from one another. This may be diagrammatically represented as follows, the point of maximum spawning, where indicated, being represented at *a*.

The exceptional cases appear to be Lochfyne and the Baltic. In the former Dr Williamson obtained 28 floating eggs of cod in a series of townettings on 5th, 6th, 7th and 8th July, and five on 9th August, 1898. In regard to the Baltic information is imperfect.

In the other cases where the evidence is most complete the correspondence of the spawning-period is noteworthy, and where the period of maximum spawning is indicated there is almost exact agreement, as at the Lofoten Islands and in the North Sea. It will not escape notice that the region in question is that in which the temperature of the sea where the cod spawns is dominated by the influence of the Gulf Stream, and that, so far as the rather imperfect information at present available goes, the critical temperature coinciding with spawning is very much the same in the different localities.

It will also be noticed that on the coast of Massachusetts the termination of spawning coincides with the period when it ceases on this side of the Atlantic, and that it begins there about the same time as it has now been found to begin off Jæderen in the North Sea. It will be of interest to ascertain whether further observations bridge over the gaps in the latter area between November and January, as on the American coast, or between June and August, or whether the periods are isolated. The autumn-spawning is obviously a very much less important phenomenon than the spring-spawning, and it requires much fuller investigation than I have been able to give to it. It appears to be the only case, with the exception of the herring, where a spring- and an autumn-spawning have been determined for the same species, and it would be interesting to discover whether the spawners belong to different races, as with the herring. In view of the imperfection of existing records, moreover, it would be of value if a fixed number of the cod and other important food-fishes landed were examined periodically, as at bi-monthly intervals, at a few convenient selected points along the coasts within the region of their distribution, in order to determine the condition of their reproductive organs and the percentage spawning. In course of time and in conjunction with the temperature observations now being so extensively made, the limit of the spawning-periods might

then be ascertained with precision and brought into relation with the temperatures; and it is not unlikely that the authorities on the other side of the Atlantic — in Newfoundland, Canada and the United States — would be willing to co-operate with the Bureau of the I. C. in this work, for the cod-fisheries there are extremely important.

I have to thank Dr Hoek, the General Secretary, for courteously supplying the temperature observations referred to above, and for the translations on p. 13.

A NEW MARK FOR FISH

BY

T. WEMYSS FULTON

In the experiments on the marking of fishes to ascertain their migrations which I carried on in the years 1889—1892, black silk-cord was used to tie a small numbered metal disc to the tail of the fish[1]). The method was abandoned in favour of Petersen's method, which injures the fish less, and is the one now generally employed; but the experiments incidentally revealed the fact that the silk cord was practically indestructible in sea-water and retained its strength after between two and three years immersion in the sea. Further, it is a matter of common observation that where ordinary printed paper is soaked in water, the print, or ink, does not become blurred but remains legible; and as the resisting quality of the black silk cord evidently did not reside either in its form or its colour, it occurred to me that a convenient and durable mark or label for attaching to the fish might be found in silk ribbon, upon which could be printed the most ample directions to the person who found the fish, or into whose hands it might come, as to what he ought to do with it. A number of pieces of pure silk, silk ribbon, and satin, of various colours as well as white, had words printed on them by a printer, in the ordinary way, and were immersed in sea-water at the end of last October, in order to test the durability of the material and the legibility of the printing after prolonged immersion. The test has, so far, been successful. After the lapse of three months, the printing remains quite legible, and the material in most cases appears to be as strong as when it was placed in the sea-water. In some instances, however, the strength of the ribbon was materially impaired; the ribbon in such cases being thin, coloured, and, I understand, mixed with cotton, i. e. not pure silk. On 14th December a piece of mode-

[1]) Eleventh Ann. Rep. Fishery Board for Scotland. Part III. p. 176. (1893).

rately thin silk ribbon, 9 mm. broad, was tested, and it was found to rupture with a weight of 4538 grammes. It was then placed in sea water and on 30th January on again being tested it ruptured when the weight reached 4473 grammes, showing therefore a slight diminution in strength in the interval of 46 days.

There is, however, a very simple process by which all doubt as to the durability of the material or the legibility of the printing after prolonged immersion may he removed, viz. by dipping the printed silk in melted paraffin wax. This penetrates the fibres and forms an impervious covering effectually excluding the water, while the printing can easily be read through the transparent coating, even where it is of some thickness. In this connection it may be stated that in the experiments made some years ago on the movement of the surface waters, wooden drifters were employed, to which were fixed printed cards (paper) which had been similarly coated with paraffin-wax and through which the directions were read; and these were found to resist the acton of the water effectively.

The best material appears to be thick, white silk ribbon, coated with paraffin wax. As for the coloured ribbons the dye was in some cases removed directly by the water, or faded away under exposure; in others it seemed fixed. There appears however to be no reason for the use of coloured material.

The obvious advantage of this mark is that it enables explicit detailed instructions to be given for the guidance of the person who comes into possession of the fish, with the information — often not unimportant — that he will be rewarded for his trouble. My experience in Scotland and the experience in America, have shown that marked fishes recaptured are frequently lost to those carrying on the experiments, often because the persons who catch them are ignorant as to what to do with them, and sometimes because they do not think the matter worth troubling about. In some cases moreover it is known that the mark escapes notice until the fish is in the possession of the consumer, and then it is only by the merest chance that the circumstance becomes known.

It is clearly of importance that as many as possible of the marked fishes that are caught should be returned, not merely in connection with the study of their migrations and growth, but also in order to determine (what is probably of greater consequence) the proportion within a given area which fall a prey to man.

From the lightness of the material and the ease with which it may be folded or rolled into small bulk, it is evident that the printed message may be made as full as any one can desire. In the sample I would recommend for adoption in the North Sea (Nr. 1) in which the directions are printed in three languages, the weight of the plain

silk is 0.28 grammes; when coated with paraffin-wax, after half-a-dozen dippings, it weighs about 1.5 grammes. Other examples are shown in Nr. 2 and Nr. 3. Another advantage is that the mark may be made conspicuous or inconspicuous and the use of a conspicuous mark in certain cases e. g. cod, is, I believe, of importance.

The printing of the marks can be done by an ordinary printer, at an estimated cost for Nr. 1 of about one shilling a hundred, the number being subsequently added by hand, with the aid of types and printers ink, or, much more expeditiously, by the employment of one of the automatic, self-inking, numbering machines now in common use.

As regards the attachment to the fish the mark may be used along with

Sc. a. 647 Fishery Board. Reward

Nr. 2.

any of the methods now employed, as for example that of Petersen for flatfishes; the silver-clasp introduced by Archer for marking salmon[1]) and adopted by Calderwood, Landmark, and others, which is fixed

Sc. b. 2176. Send this fish to Marine Laboratory Aberdeen. Reward

Nr. 3.

through the base of the dorsal fin; the fine copper-wire used by Smith to attach a small copper tag to the base of the caudal or dorsal fins in the cod[2]) or the methods described by Trybom for the salmon and the eel[3]).

Sc. a. 469.

The finder of this fish is earnestly requested to forward it, *with this label and a note of the place and date of capture*, to ..... , or to the nearest Fishery Officer or Harbour Master, when he will receive the price of the fish, the postage and a reward of two shillings.

Wer diesen Fisch findet, wird dringend gebeten, ihn *mit diesem Zettel und einer Notiz über Zeit und Ort des Fanges* an ..... oder an den nächstwohnenden Fischmeister oder Hafenmeister zu senden. Dort wird er den Preis des Fisches, die Frankaturkosten und eine Belohnung von zwei Mark bekommen.

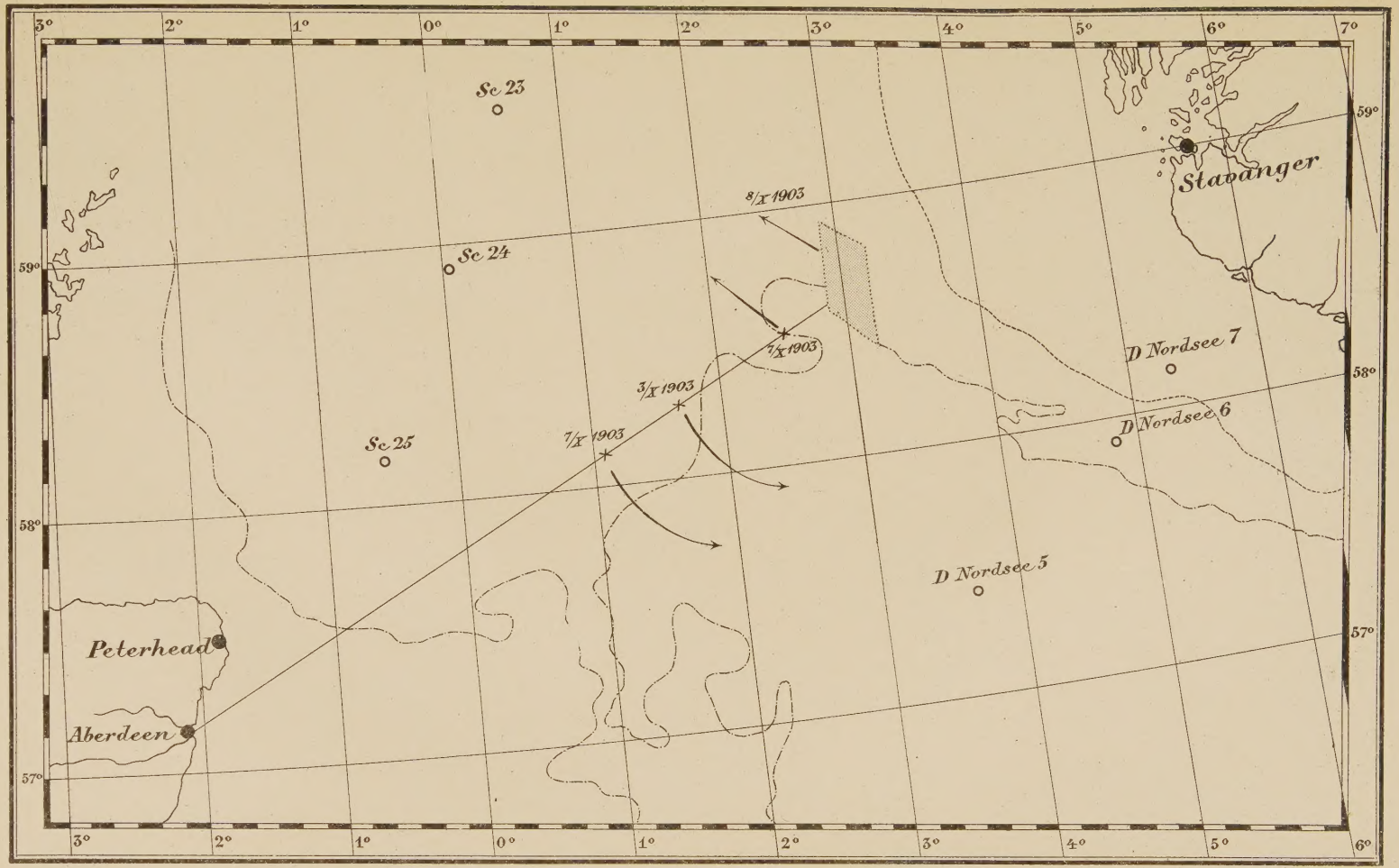
Finderen af denne Fisk anmodes om at sende samme *tilligemed denne Seddel og Oplysning om Stedet hvor og naar Fisken blev fanget* til ..... eller til nærmestboende Fiskeriinspektør eller Havnemester. Prisen for Fisken, Forsendelsesomkostningerne samt en Belønning af to Kroner vil blive betalt til Finderen.

Nr. 1.

With regard to round fishes generally I do not think there can be much question as to the applicability of the silk tag; and judging from the results already obtained by the use of Archer's & Smith's methods, it is probable that these are the best for large fishes, as

[1]) Eleventh Ann. Rep. Fishery Board for Scotland. Part II. p. 61. (1893).
[2]) Rep. U. S. Fish Commission for 1901. p. 194. (1902).
[3]) Svensk Fiskeritidskrift, 12te Årg., Häft 4. p. 195. (1903).

the cod and other large gadoids, or for any other fish where the fin-rays are sufficiently stout. With flatfishes however it is necessary to bear in mind their habit of "sanding" themselves. Whether the attrition would prove sufficient to wear off the paraffin layer or wear away the silk is a moot-point. But in any case the difficulty can be obviated by enclosing the tag in a suitable covering, as part of a quill or fine glass tube, through either of which the print can be seen.



Spawning of the Cod in Autumn in the North Sea

Ont paru dans la même série (PUBLICATIONS DE CIRCONSTANCE):

N° 1. C. G. Joh. Petersen, How to distinguish between mature and immature Plaice throughout the Year. 8 p. 1 pl. July 1903. Kr. 1.

N° 2. Martin Knudsen, On the Standard-Water used in the hydrographical Research until July 1903. 9 p. July 1903. Kr. 0,50.

N° 3. Die Literatur der zehn wichtigsten Nutzfische der Nordsee. In monographischer Darstellung. 112 S. 10 T. August 1903. Kr. 3.

The Literature of the Ten Principal Food Fishes of the North Sea. In the form of compendious monographs. 108 p. 10 pl. August 1903. Kr. 3.

N° 4—5. Martin Knudsen, Ueber den Gebrauch von Stickstoffbestimmungen in der Hydrographie.

— — , Gefrierspunkttabelle für Meerwasser.

Zusammen 13 S. September 1903. Kr. 0,75.

N° 6. Harry M. Kyle, On a new Form of Trawl Net, designed to fish in midwater as well as on the ground. Preliminary notice. 8 p. November 1903. Kr. 0,50.

N° 7. P. J. van Breemen, Ueber das Vorkommen von *Oithona nana* Giesbr. in der Nordsee. Mit einer Karte. 24 S. November 1903. Kr. 1.

COPENHAGUE — IMPRIMERIE BIANCO LUNO